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SENSOR DEVELOPMENT THERMOSPHERIC NEUTRAL WIND MEASUREMENTS

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14. ABSTRACT

The final preparatory work toward the functional design of a flight sensor for neutral wind measurements has been completed. Extensive laboratory testing has been followed by digital control design that will allow the input drivers and the output currents to be assembled for delivery to the ground. A flexible format for energy discrimination in the retarding potential analyzer must allow for the expected geophysical variation in the velocity and temperature of the species. The instrument operation must also be synchronized to allow autonomous data reduction on the ground from a single packet of data.

15. SUBJECT TERMS

Neutral, Wind, Sensor, Thermosphere

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1. INTRODUCTION

Activity this year is restricted to the final design and simulation efforts required for a flight verification of the sensor designed and built for flight on the Communication/Navigation Outage Forecast System (C/NOFS) satellite. The instrumentation includes newly designed devices to measure the local neutral wind velocity which should be retrievable along the C/NOFS satellite orbit below about 500 km altitude. Precious reports have described the principals of operation and the detailed sensor design characteristics that were used to determine the required spacecraft interfaces. Following the acquisition of support from NASA to build the spaceflight sensors and collaboration with AFRL and SMC for the spacecraft and launch, the work sponsored by this contract has been directed to precise definition of the requirements for optimal performance of the instrument and studies of the internal instrument optics for suppression of photoemission in the so-called ram wind sensor.

2. INSTRUMENTATION

Two sensors have been designed and prepared for flight on the C/NOFS payload. The cross-track wind sensor (CTS) measures the arrival angle of the neutral gas with respect to the ram direction and the ram wind sensor (RWS) measures the velocity of the neutral gas along the ram direction. The principles of operation and the performance characteristics of each of these sensors have been described in previous reports. Here we restrict our attention to the final design features of the RWS made during the construction of a flight instrument and the simulation of flight data for verification of the ground software.

2.1 Ram Wind Sensor

The ram wind sensor derives the velocity along the ram direction by performing a retarding potential energy analysis on an ionized fraction of the flowing neutral gas. The incident ambient ions are electrostatically deflected from the instrument axis so that only the ions produced from the flowing neutral beam have access to the electron-multiplier detector. The principal objective is to ionize a fraction of the flowing neutral beam and perform a retarding potential analysis on the ionized fraction. The relatively low ionized fraction is detected with an electron multiplier that is shielded from solar photons by being placed behind an aperture. Deflection of the ion stream into the analyzer is accomplished by the high negative potential applied to the multiplier cone. To ensure a low sensitivity to solar photons there are no single or double bounce paths directly into the multiplier and the surfaces of the deflector plate and the rear of the analyzer compartment are coated with black nickel to suppress secondary emission.

2.2 Ram Wind Simulation Software.

Simulation of the ram wind sensor is more complex since it requires that we anticipate changes in the instrument performance in space that are not reproducible in the laboratory. For this purpose we devise eight different retarding voltage sweeps designed to accommodate differing energy distributions and determine the in-flight background currents. The sweep formats are illustrated in figure 1. We have designed one sweep to verify the ion optics. By setting the RV to zero we allow diagnosis of the incoming neutral beam, or, with the deflector and filaments off we can diagnose the ambient ions. The other RV sweeps are designed to accommodate variations in the energy distribution caused by the electron beam itself. We expect these influences to be small, but since ionizing a flowing beam is not easily accomplished in the laboratory we have allowed for both a narrow and broad temperature distribution.

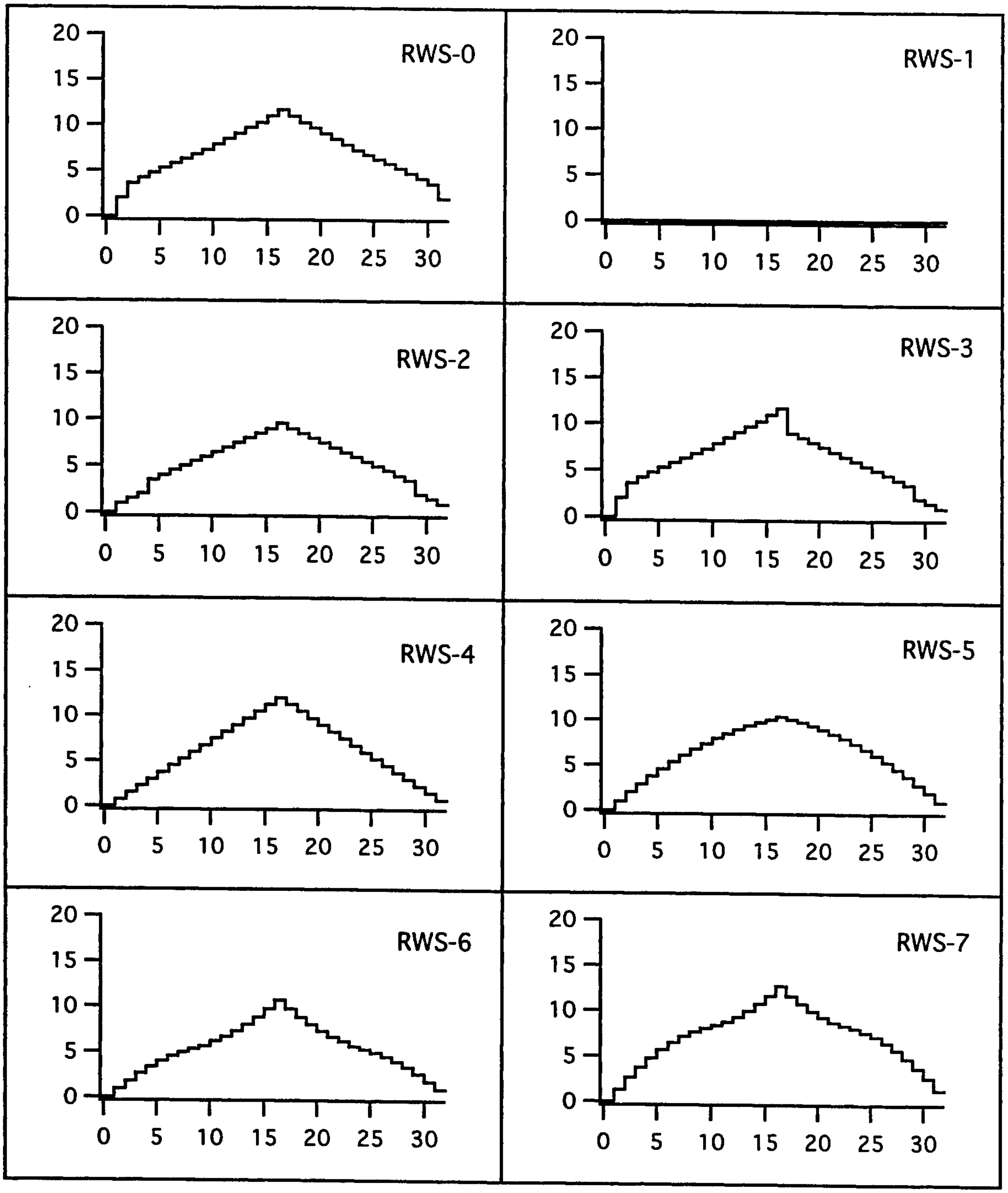

Figure 1. RWS Sweep Sequences Used to Accommodate C/NOFS Operating Conditions.

We emphasize that the techniques employed will not provide the ambient neutral temperature and require only that the resulting ions possess a Maxwellian temperature in order to specify changes in the bulk flow

2.3 Cross-Track Simulation Software.

In order to produce flight-ready ground software at AFRL we have constructed instrument simulators and produced flight data packets for testing purposes. For the cross-track sensor it is necessary to simulate the pressure enhancement in the chambers and the performance of the logarithmic and linear amplifiers that derive the pressure ratios. This information is obtained from detailed laboratory calibrations of the electronics, nominal values for the chamber temperature and the ambient temperature and pressure. The data are subsequently run through a 12-bit a/d converter. The time series telemetry data is rather simply interpreted since each difference amplifier output represents a pressure ratio that is linearly proportional to either the horizontal or the vertical neutral gas arrival angle. When the pressure equalization (PE) valve is open the logarithmic inputs are all equal and the difference reflects a difference in the electrometer constants. This difference may be accounted for in subsequent outputs when the PE valve is closed.

2.4 Level-0 Data Packets.

The simulated data from the Neutral Wind Meter (NWM) and from the Ion Velocity Meter (IVM) are assembled into data packets for transmission to the ground. Separate data packets are assembled for the NWM and IVM. For the NWM data packets represent a 4-second sequence of data. Each packet will contain a header that provides a time tag reference to universal time and instrument status that allows the instrument outputs to be interpreted. All these data are included in simulation routine so that ground software may be evaluated.

3. CONCLUSIONS

This year's research effort has been carried out at a relatively low level commensurate with the available funding. Since this project has been transitioned to a fully funded NASA activity, support from this grant has been used to augment the instrument and data verification operations that are an essential part of the pre-launch software development. Our overall activity has resulted in the design and verification of a robust space instrument to measure the F-region neutral wind vector. All our original success criteria at this level have been met. We can now confidently look forward to obtaining measurements of the equatorial F-region neutral wind during the C/NOFS program.